

What is claimed is:

1. An apparatus for measuring an amount of oil in a flow of fluid, the apparatus comprising:

- 5 a housing defining an interior passage configured to pass a flow of fluid therethrough;
- a capacitance sensor configured to respond to a capacitance of the flow of fluid, the capacitance sensor being disposed within the interior passage of the housing and coupled to conductors; and
- 10 a conductance sensor configured to measure conductance of the flow of fluid, the conductance sensor being disposed on the interior passage of the housing and being further configured to generate a conductance signal.

2. The apparatus of Claim 1, further comprising a control module operably coupled to the conductors and the conductance signal, the control module being further configured to measure a capacitance of the flow of fluid and generate a first signal representative of the capacitance of the flow of fluid and convey a second signal representative of the conductance of the flow of fluid.

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3. The apparatus of Claim 1, wherein the housing includes a first end coupled with an outlet of a source of the flow of fluid and a second end.

4. The apparatus of Claim 3, wherein the first and second ends of the housing include flanges such that the flanges are coupleable with flanged pipe sections.

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5. The apparatus of Claim 1, wherein the housing includes one of a steel pipe, an iron pipe, a copper pipe, an opaque PVC pipe, a translucent PVC pipe, or a clear PVC pipe.

6. The apparatus of Claim 1, further comprising an orifice plate disposed within the interior passage of the housing, the orifice plate being configured to restrict the flow of fluid through the interior passage such that the flow of fluid is directed over the capacitance sensor and the conductance sensor.

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7. The apparatus of Claim 1, wherein the capacitance sensor is disposed on opposing sides of the interior passage of the housing.

8. The apparatus of Claim 2, further comprising an analog-to-digital converting circuit configured to convert the first signal into a first digital signal and to convert the second signal into a second digital signal.

9. The apparatus of Claim 8, wherein the control module includes an interface  
5 configured to communicate the first and second digital signals.

10. The apparatus of Claim 9, wherein the interface includes an RS-232 interface.

11. The apparatus of Claim 9, further comprising a first telemetry module configured to receive the first and second digital signals from the interface and to communicate the first and second digital signals to a data collection device.

10 12. The apparatus of Claim 9, further comprising a computing module configured to receive the first and second digital signals from the interface and compute a relative amount of oil in the flow of fluid, the computing module being further configured to generate a relative amount of oil signal.

15 13. The apparatus of Claim 12, wherein the computing module is configured to use the first digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicates that approximately not less than one-half of the flow of fluid includes oil, and to use the second digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicate that approximately not more than one-half of the flow of fluid includes oil.

20 14. The apparatus of Claim 12, further comprising a second telemetry module configured to communicate the relative amount of oil signal to the data collection device.

25 15. The apparatus of Claim 13, further comprising a flow rate sensor disposed on the interior passage of the housing, the flow rate sensor being configured to measure a total rate of the flow of fluid passing through the interior passage of the housing and to generate a flow rate signal.

16. The apparatus of Claim 15, wherein the computing module is further configured to combine the relative amount of oil in the flow of fluid with the flow rate signal for calculating a total flow rate of oil in the flow of fluid, the computing module being further configured to generate a total flow rate of oil signal.

17. The apparatus of Claim 16, further comprising a third telemetry module configured to communicate the total flow rate of oil signal to the data collection device.

18. The apparatus of Claim 16, further comprising at least one additional fluid property sensor disposed on the interior passage of the housing, the at least one additional fluid property sensor being configured to measure an additional fluid property of the flow of fluid passing through interior passage of the housing and generate a fluid property signal.

19. The apparatus of Claim 18, wherein the computing module is further configured to combine the fluid property signal with the total flow rate of oil in the flow of fluid for calculating an adjusted total flow rate of oil in the flow of fluid, the computing module being further configured to generate an adjusted total flow rate of oil signal.

20. The apparatus of Claim 18, further comprising a fourth telemetry module configured to communicate the adjusted amount of oil signal to the data collection device.

21. The apparatus of Claim 18, wherein the at least one additional fluid property sensor includes at least one pressure sensor configured to measure a pressure of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid pressure signal.

22. The apparatus of Claim 18, wherein the at least one additional fluid property sensor includes a density sensor configured to measure a density of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid density signal.

23. The apparatus of Claim 22, wherein the density sensor includes a nuclear density sensor.

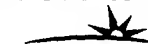
24. The apparatus of Claim 18, wherein the at least one additional fluid property sensor includes a temperature sensor configured to measure a temperature of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a temperature signal.

25. The apparatus of Claim 3, further comprising a gas separator coupled between the first end of the housing and the source of the flow of fluid, the gas separator being configured to allow separation of gas from the flow of fluid.



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26. A system for measuring an amount of oil in a flow of fluid, the apparatus comprising:

- a housing defining an interior passage configured to pass a flow of fluid therethrough;
- 5 a capacitance sensor configured to respond to a capacitance of the flow of fluid, the capacitance sensor being disposed within the interior passage of the housing and coupled to conductors;
- a control module operably coupled to the conductors, the control module being configured to measure a capacitance of the flow of fluid and generate a first analog signal representing the capacitance of the flow of fluid;
- 10 a conductance sensor configured to measure conductance of the flow of fluid disposed on the interior passage of the housing and generate a second analog signal representing the conductance of the flow of fluid;
- an analog-to-digital converter receiving the first and second analog signals and configured to convert the first analog signal into a first digital signal and to convert the second analog signal into a second digital signal;
- 15 a computing module configured to receive the first and second digital signals and compute a relative amount of oil in the flow of fluid, the computing module being further configured to generate a relative amount of oil signal; and
- 20 an interface configured to receive the relative amount of oil signal and communicate the relative amount of oil signal.

27. The system of Claim 26, wherein the housing includes a first end coupled with an outlet of a source of the flow of fluid and a second end.

28. The apparatus of Claim 27, wherein the first and second ends of the housing include  
25 flanges such that the flanges are coupleable with flanged pipe sections.

29. The apparatus of Claim 26, wherein the housing includes one of a steel pipe, an iron pipe, a copper pipe, an opaque PVC pipe, a translucent PVC pipe, or a clear PVC pipe.

30. The apparatus of Claim 26, further comprising an orifice plate disposed within the interior passage of the housing, the orifice plate being configured to restrict the flow of fluid  
30 through the interior passage such that the flow of fluid is directed over the capacitance sensor and the conductance sensor.



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31. The apparatus of Claim 26, wherein the capacitance sensor is disposed on opposing sides of the interior passage of the housing.

32. The apparatus of Claim 26, wherein the interface includes an RS-232 interface.

33. The apparatus of Claim 26, further comprising a first signal telemetry module  
5 configured to receive the relative amount of oil signal from the interface and to communicate the relative amount of oil signal to a data collection device.

34. The apparatus of Claim 26, wherein the computing module is configured to use the first digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicates that approximately not less than one-half of  
10 the flow of fluid includes oil, and to use the second digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicate that approximately not more than one-half of the flow of fluid includes oil.

35. The apparatus of Claim 34, further comprising a flow rate sensor disposed on the interior passage of the housing, the flow rate sensor being configured to measure a total rate  
15 of the flow of fluid passing through the interior passage of the housing and to generate a flow rate signal.

36. The apparatus of Claim 35, wherein the computing module is further configured to combine the relative amount of oil in the flow of fluid with the flow rate signal for calculating a total flow rate of oil in the flow of fluid, the computing module being further  
20 configured to generate a total flow rate of oil signal.

37. The apparatus of Claim 36, further comprising a second telemetry module configured to communicate the total flow rate of oil signal to the data collection device.

38. The apparatus of Claim 36, further comprising at least one additional fluid property sensor disposed on the interior passage of the housing, the at least one additional fluid  
25 property sensor being configured to measure an additional fluid property of the flow of fluid passing through interior passage of the housing and generate a fluid property signal.

39. The apparatus of Claim 38, wherein the computing module is further configured to combine the fluid property signal with the total flow rate of oil in the flow of fluid for calculating an adjusted total flow rate of oil in the flow of fluid, the computing module being  
30 further configured to generate an adjusted amount of oil signal.



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40. The apparatus of Claim 39, further comprising a third telemetry module configured to communicate the adjusted amount of oil in the flow of fluid to the data collection device.

41. The apparatus of Claim 38, wherein the at least one additional fluid property sensor includes at least one pressure sensor configured to measure a pressure of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid pressure signal.

42. The apparatus of Claim 38, wherein the at least one additional fluid property sensor includes a density sensor configured to measure a density of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid density signal.

43. The apparatus of Claim 42, wherein the density sensor includes a nuclear density sensor.

44. The apparatus of Claim 38, wherein the at least one additional fluid property sensor includes a temperature sensor configured to measure a temperature of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a temperature signal.

45. The apparatus of Claim 27, further comprising a gas separator coupled between the first end of the housing and the source of the flow of fluid, the gas separator being configured to allow separation of gas from the flow of fluid.

46. A system for measuring an amount of oil in a flow of fluid, the apparatus comprising:

- a housing defining an interior passage configured to pass a flow of fluid therethrough;
- a capacitance sensor configured to respond to a capacitance of the flow of fluid, the capacitance sensor being disposed within the interior passage of the housing and coupled to conductors;
- a control module operably coupled to the conductors, the control module being configured to measure a capacitance of the flow of fluid and generate a first analog signal representing the capacitance of the flow of fluid;

a conductance sensor configured to measure conductance of the flow of fluid disposed on the interior passage of the housing and generate a second analog signal representing the conductance of the flow of fluid;

5 a flow rate sensor disposed on the interior passage of the housing, the flow rate sensor being configured to measure a total rate of the flow of fluid passing through interior passage of the housing and generate a third analog signal representing the total flow rate signal;

10 an analog-to-digital converting receiving the first, second, and third analog signals and configured to convert the first analog signal into a first digital signal, to convert the second analog signal into a second digital signal, and to convert the third analog signal into a third digital signal;

a computing module configured to receive the first, second, and third digital signals and compute a total flow rate of oil in the flow of fluid, the computing module being further configured to generate a total flow rate of oil signal; and

15 an interface configured to receive the total flow rate of oil signal and communicate the total flow rate of oil signal.

47. The system of Claim 46, wherein the housing includes a first end coupled with an outlet of a source of the flow of fluid and a second end.

48. The apparatus of Claim 47, wherein the first and second ends of the housing include  
20 flanges such that the flanges are coupleable with flanged pipe sections.

49. The apparatus of Claim 46, wherein the housing includes one of a steel pipe, an iron pipe, a copper pipe, an opaque PVC pipe, a translucent PVC pipe, or a clear PVC pipe.

50. The apparatus of Claim 46, further comprising an orifice plate disposed within the interior passage of the housing, the orifice plate being configured to restrict the flow of fluid  
25 through the interior passage such that the flow of fluid is directed over the capacitance sensor and the conductance sensor.

51. The apparatus of Claim 46, wherein the capacitance sensor is disposed on opposing sides of the interior passage of the housing.

52. The apparatus of Claim 46, wherein the interface includes an RS-232 interface.



53. The apparatus of Claim 46, further comprising a first signal telemetry module configured to receive the total flow rate of oil signal and to communicate the total flow rate of oil signal to a data collection device.

54. The apparatus of Claim 46, wherein the computing module is configured to use the first digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicates that approximately not less than one-half of the flow of fluid includes oil, and to use the second digital signal to calculate the relative amount of oil in the flow of fluid when at least one of the first and second digital signals indicate that approximately not more than one-half of the flow of fluid includes oil.

55. The apparatus of Claim 46, further comprising at least one additional fluid property sensor disposed on the interior passage of the housing, the at least one additional fluid property sensor being configured to measure an additional fluid property of the flow of fluid passing through interior passage of the housing and generate a fluid property signal.

56. The apparatus of Claim 55, wherein the computing module is further configured to combine the fluid property signal with the total flow rate of oil in the flow of fluid for calculating an adjusted total flow rate of oil in the flow of fluid.

57. The apparatus of Claim 56, further comprising a second telemetry module configured to communicate the total flow rate of oil in the flow of fluid to the data collection device.

58. The apparatus of Claim 55, wherein the at least one additional fluid property sensor includes at least one pressure sensor configured to measure a pressure of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid pressure signal.

59. The apparatus of Claim 55, wherein the at least one additional fluid property sensor includes a density sensor configured to measure a density of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a fluid density signal.

60. The apparatus of Claim 59, wherein the density sensor includes a nuclear density sensor.



61. The apparatus of Claim 55 wherein the at least one additional fluid property sensor includes a temperature sensor configured to measure a temperature of the flow of fluid passing through the interior passage of the housing and the fluid property signal includes a temperature signal.

5        62. The apparatus of Claim 47, further comprising a gas separator coupled between the first end of the housing and the source of the flow of fluid, the gas separator being configured to allow separation of gas from the flow of fluid.

63. A method for measuring an amount of oil in a flow of fluid, the apparatus comprising:

10            passing a flow of fluid from a source of fluid through a housing;  
              measuring a capacitance of the flow of fluid as the flow of fluid passes through the housing;  
              measuring the conductance of the flow of fluid as the flow of fluid passes through the housing;  
15            calculating a relative amount of oil in the flow of fluid based on the capacitance of the flow of fluid when at least one of the capacitance and the conductance indicates that approximately not less than one-half of the flow of fluid includes oil and calculating the relative amount of oil in the flow of fluid based on the conductance when at least one of the capacitance and the  
20            conductance indicates that approximately not more than one-half of the flow of fluid includes oil; and  
              generating a relative amount of oil signal.

64. The method of Claim 63, further comprising communicating the relative amount of oil signal to a data collection device.

25        65. The method of Claim 63, further comprising measuring a rate of flow of fluid through the housing.

66. The method of Claim 65, further comprising calculating a total flow rate of oil in the flow of fluid by combining the rate of flow of fluid with the relative amount of oil in the flow of fluid and generating a total flow rate of oil signal.

30        67. The method of Claim 66, further comprising communicating the total flow rate of oil signal to the data collection device.



68. The method of Claim 66, further comprising measuring at least one additional fluid property of the flow of fluid passing through the housing.

69. The method of Claim 68, further comprising calculating an adjusted total flow rate of oil in the flow of fluid by combining the total flow rate of oil in the flow of fluid with the  
5 additional property of the flow of fluid and generating an adjusted amount of oil signal.

70. The method of Claim 69, further comprising communicating the adjusted total flow rate of oil signal to the data collection device.

71. The method of Claim 68, wherein the at least one additional fluid property includes fluid pressure.

10 72. The method of Claim 68, wherein the at least one additional fluid property includes fluid density.

73. The method of Claim 68, wherein the at least one additional fluid property includes fluid temperature.

74. The method of Claim 63, further comprising separating gas from the flow of fluid  
15 before directing the flow of fluid from the source of fluid through the housing.

75. A method for measuring an amount of oil in a flow of fluid, the apparatus comprising:

passing a flow of fluid from a source of fluid through a housing;  
measuring a capacitance of the flow of fluid as the flow of fluid passes through  
20 the housing;  
measuring the conductance of the flow of fluid as the flow of fluid passes through the housing;  
measuring a rate of flow of fluid through the housing;  
calculating a relative amount of oil in the flow of fluid based on the capacitance  
25 of the flow of fluid when at least one of the capacitance and the conductance indicates that approximately not less than one-half of the flow of fluid includes oil and calculating the relative amount of oil in the flow of fluid based on the conductance when at least one of the capacitance and the conductance indicates that approximately not more than one-half of the flow  
30 of fluid includes oil;



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calculating a total flow rate of oil in the flow of fluid by combining the rate of  
flow of fluid with the relative amount of oil in the flow of fluid; and  
generating a total flow rate of oil signal.

76. The method of Claim 75, further comprising communicating the total flow rate of  
oil signal to a data collection device.

77. The method of Claim 75, further comprising measuring at least one additional fluid  
property of the flow of fluid passing through the housing.

78. The method of Claim 77, further comprising calculating an adjusted total flow rate  
of oil in the flow of fluid by combining the total flow rate of oil in the flow of fluid with the  
additional property of the flow of fluid and generating an adjusted total flow rate of oil  
signal.

79. The method of Claim 78, further comprising communicating the adjusted total flow  
rate of oil signal to the data collection device.

80. The method of Claim 77, wherein the at least one additional fluid property includes  
fluid pressure.

81. The method of Claim 77, wherein the at least one additional fluid property includes  
fluid density.

82. The method of Claim 77, wherein the at least one additional fluid property includes  
fluid temperature.

83. The method of Claim 77, further comprising communicating the adjusted total flow  
rate of oil in the flow of fluid to the data collection device.

84. The method of Claim 75, further comprising separating gas from the flow of fluid  
before directing the flow of fluid from the source of fluid through the housing.

